EIM Quarterly Benefit Report Methodology

Effective with Q4 2025 EIM benefits report

Prior to the creation of this document, the methodology for the benefits calculation was posted in a technical bulletin and in the benefit report itself. This document consolidates these prior materials into a concise paper for easier understanding of how the EIM benefits are calculated.

The total EIM benefit is the cost saving of the EIM dispatch compared with a counterfactual (CF) without EIM dispatch. The counterfactual dispatch meets the same amount of real-time load imbalance in each BAA without EIM transfers between neighboring EIM BAAs. For an EIM BAA, the benefit can take the form of cost savings or profit or their combination. A BAA will be likely to have energy cost savings when the BAA is importing energy economically, or its base schedules are being optimized by the EIM. To the extent an entity base schedule is optimized prior its submission into the EIM, the benefits may be lessened when compared to an entity that has not submitted optimized base schedules into the EIM. A BAA will be likely to have an energy profit when the BAA is exporting energy economically to other BAAs and being paid a price higher than the bid cost. A BAA other than the ISO may also have a GHG profit when the resource is allocated GHG MWs and is receiving GHG revenue based on marginal GHG cost that is likely higher than its own GHG bid cost.

For each 5-minute interval, the **EIM benefit for a BAA = counterfactual dispatch cost – (EIM dispatch cost + transfer cost + flex ramp transfer cost) + GHG revenue – GHG cost.** The 5-minute level EIM benefits are then aggregated each month with a multiplier 1/12 to convert ($/5 min) to a dollar amount.

EIM Benefit Calculation Components

EIM Dispatch Cost

The total dispatch cost for a BAA for an interval is the sum of all the unit level EIM dispatch costs for that BAA for that interval.

For all BAAs other than CAISO, the dispatch cost only includes variable dispatch cost, i.e. the bids submitted by the corresponding Scheduling Coordinator.

For the ISO's long start units, we only consider variable dispatch cost. For the ISO's short start units, we use a generic cost formula, which includes variable dispatch cost, no load cost, and startup cost. Specifically, the three-part cost for short start units includes:

- The variable dispatch cost of RTD, which is equal to the bid cost associated with the delta instruction above or below the base schedule for each interval,
- the no load cost associated with the incremental dispatch, which is equal to the no load cost divided by Pmax, then multiplied by the delta instruction from the base schedule,
- The startup cost associated with the incremental dispatch, which is equal to the startup cost divided by the minimum online hours, then multiplied by the delta instruction from base schedule divided by the Pmax.

The purpose of this generic cost formula is to evaluate cost differences between EIM dispatches and counterfactual dispatches without performing sophisticated unit commitment simulations. Prior to Q1 2016, only variable dispatch cost was considered in the EIM benefit calculation. With NV Energy joining EIM and improving the transfer capabilities from and to the ISO, we observed a significantly increased transfer volume in EIM. The higher transfer volume cannot be sufficiently replaced by resources online in EIM without committing or de-committing resources, and hence the ISO adopted a three-part cost formula as of Q1 2016 to allow for unit commitment decisions to better evaluate the production difference between EIM and the counterfactual dispatch of the ISO. The unit commitment decisions were made only for short start units that were not combined cycle units. The combined cycle units have complicated models in EIM, so their counterfactual commitment status is fixed at the EIM commitment status to avoid oversimplification.

We approximate the ISO's commitment costs by converting the startup cost and no load cost into variable dispatch cost, assuming a committed short start resource will be fully loaded for minimum online hours. For each supply segment, the corresponding three-part variable cost is equal to

bid_price + no_load_cost/Pmax + startup_cost/min_up_hour/Pmax

Note the formula above converts startup cost (in unit $) and no load cost (in unit $/h) into variable dispatch cost (in unit $/MWh). By doing this, the commitment for the ISO's short start units can be determined based on the economic metric order of the three-part variable cost.

Transfer Cost

As a convention, select the importing direction as the default direction for a transfer, so the importing transfer is positive and the exporting transfer is negative. The transfer cost is equal to the transfer MW times the transfer price. For transfers involving the ISO in either the importing direction or the exporting direction, the transfer price is the other BAA's LMP plus the shadow price of the transfer. In doing this, the congestion rent on the transfer will be fully attributed to the other BAA. For transfers involving two BAAs that are not the ISO, the transfer price will split the congestion shadow price on the transfer in half. For an importing BAA, the transfer price is the LMP of the BAA minus half of the absolute value of the transfer shadow price. For an exporting BAA, the transfer price is the LMP of the BAA plus half of the absolute value of the transfer shadow price. The transfer could occur in both the 15-minute market and the 5-minute market. In this case, the transfer cost is 15-minute transfer * 15-minute transfer price + (5-minute transfer – 15-minute transfer) * 5-minute transfer price for each 5-minute interval.

For the prices (LMPs) used in the EIM benefits, the calculation uses the corresponding ELAP prices of each EIM area. For CAISO prices, the calculation uses the prices associated at the corresponding scheduling points at the Malin, Palo Verde, El Dorado or Rancho Seco interties. The specific scheduling price to be used among these intertie locations is in relationship to the benefit calculated to a specific EIM area. For instance, when calculating the benefits between PAC West and CAISO, the calculation will use Malin scheduling point price (CAISO side).

Flex Ramp Transfer Cost

In 2016, the ISO implemented the flexible ramping products to replace flexible ramping constraints. The flexible ramping products are available capacities to handle future load and generation uncertainties, and include both the upward ramping capacity and downward ramping capacity. They may be put aside in RTD to enhance dispatch flexibility. One BAA's flexible ramping capacities in RTD may be helping other BAAs. In this case, the BAA that exports flexible ramping products should receive payment from other BAAs to compensate the dispatch cost of keeping flexible ramping capacities, and the BAA that imports flexible ramping products should pay other BAAs to reflect its dispatch cost to handle future uncertainties. This is similar to how energy transfer is treated in the EIM benefit calculation. Energy transfer is explicitly modeled in EIM, while flexible ramping transfer is not. We need to calculate a BAA's flexible ramping transfer. First, we allocate the system flex ramp award to each BAA in proportion to its individual BAA requirement. Then we calculate the flex ramp transfer as the BAA's RTD flexible ramping award minus its allocated share. The flex ramp transfer cost is equal to the flex ramp transfer multiplied by the EIM whole footprint flex ramp shadow price.

Counterfactual Dispatch Cost

The counterfactual dispatch for an EIM BAA mimics the market operations without importing or exporting through the EIM transfers. The counterfactual dispatch moves units inside the BAA to meet the same real-time load imbalance as the EIM dispatch based on economic merit order without considering transmission constraints. For PacifiCorp, the transfer limit between PACE and PACW is enforced in the counterfactual dispatch.

Neglecting transmission constraints in a BAA tends to underestimate the EIM benefit. The magnitude depends on how significant the congestion is. Severe congestion impacting EIM benefits was not observed until October 2017, where transmission congestion happened between the generation in Wyoming and PACE's load in PacifiCorp. The impact of this congestion to the EIM benefit calculation can be demonstrated with the following example.

Assume in PACE, load increased 10 MW from the base schedule, generation decreased 100 MW from the base schedule, and PACE imported 110 MW in EIM. Note that energy is balanced in PACE with 110 MW of transfer import replacing 100 MW of generation and serving 10 MW of load above the base schedule. Assume the decremented generation cost is $20/MWh, and the import cost is $120/MWh. From an economic standpoint, the EIM dispatched the resources out-of-merit with high cost supply being incremented and low cost supply being decremented. If we were to calculate the EIM benefit ignoring the congestion effect, the benefit will be negative. The calculation is as follows:

> EIM dispatch cost = -100 MW * $20 = –$2,000.
>
> EIM transfer cost = 110 MW * $120 = $13,200.
>
> Counterfactual dispatch cost = 10 MW * $20 = $200.
>
> For simplicity, ignore flex ramp and GHG. The EIM benefit is calculated as $200 – (–$2,000 + $13,200) = –$11,000.

To better understand the root cause of the negative benefit, we break the calculated benefit into two components: infeasible base schedule and infeasible counterfactual.

1. Infeasible base schedule: In the EIM, the imported $120 transfer replaced 100 MW of $20 internal generation, and produced a negative benefit equal to 100*($20-$120) = -$10,000. The extra dispatch cost in EIM is not due to economics, but due to infeasible base schedules for certain constraints, which forces the EIM to mitigate congestion, and incurs additional cost. For this reason, we need to add the congestion management cost to the counterfactual dispatch cost to reflect the need to perform the same congestion management dispatch as in the EIM. In the example, we add $10,000 to the counterfactual dispatch cost.

2. Infeasible counterfactual: In the counterfactual, the merit order dispatch did not know that dispatching up the $20 generation would overload the transmission, and produced a negative benefit equal to 10*($20-$120) = -$1,000. The counterfactual should recognize the economic $20 supply is subject to transmission congestion, and cannot be dispatched. Therefore, in the counterfactual dispatch, for increased net load, we dispatch only supply offers with a bid price >= the transfer LMP. For decreased net load, we dispatch down only supply offers with a bid price <= the transfer LMP. In the example, the net load is 10 MW, so we only dispatch resources that bid above $120, assume these supplies cost $125/MWh.

With these two enhancements, we revise the benefit calculation as follows:

EIM dispatch cost = -100 MW * $20 = –$2,000.

EIM transfer cost = 110 MW * $120 = $13,200.

Counterfactual dispatch cost = 10 MW * $125 + $10,000 = $11,250.

The new EIM benefit is calculated to be $11,250 – (–$2,000 + $13,200) = $50.

These enhancements only apply when we detect significant congestion indicated by the LMP difference between the BA's ELAP and DGAP greater than a tolerance setting. Currently, the tolerance is set to $5/MWh.

The counterfactual dispatch makes unit commitment decisions only for the ISO's short start units. The unit commitment decisions are based on the generic three-part variable cost formula, which has converted startup cost and no load cost into variable dispatch cost, so unit commitment can be determined by the economic metric order of the three-part cost.

Prior to the 2016 Q4 report, we used the resources' RTD dispatching limits from the EIM in the counterfactual. The EIM dispatching limits are 10-minute ramp limited in RTD, and they may be overly constraining for the counterfactual theoretically. The counterfactual will replace the transfers with internal dispatches, but it does not need to do it within 10-minute timeframe. When EIM transfer volumes are moderate relative to the EIM dispatching range, this limitation may not be a real problem, because the EIM dispatch range is mostly sufficient to replace the transfers. As the EIM footprint increases, the transfer volume between BAAs also increases. We observed that some EIM transfers exceeded 1,000 MW frequently. The EIM dispatching range started to show its limitation. In Q4 of 2016, we expanded the resources' dispatching range to base schedule and FMM dispatching limits. From Q2 of 2017, we decided not to use EIM calculated limits and instead construct the dispatching range based on the resource's economic bid range to discount the capacity that is not available due to ancillary services provisions, and in the case of variable energy resources, limit the maximum bid range by the forecasted output. This logic was based on bids and forecast available from the FMM market.

Starting in Q4 2025, the bid range logic has been enhanced to rely on RTD market data instead of the previous approach. This adjustment offers a more accurate reflection of actual market conditions in two key aspects. Dispatches and transfers from WEIM solution are based on the RTD markets and using bids from RTD market will better align. Second, the forecasted output for variable energy resources often differs between the FMM and RTD markets. By using the RTD forecast to estimate load imbalance in the benefit calculation, it more accurately reflects actual RTD conditions. It also eliminates imbalances that reflect forecast differences and focus on imbalances from actual market redispatches.

To illustrate the logic prior to the Q4 2025 enhancement, consider the following example:

A wind resource has a base schedule of 100 MW. Its FMM forecast is 73 MW, while its RTD forecast is 16 MW.

In the FMM market, a range will be made available for the resource up to the 73 MW forecast. Similarly, in the RTD market, a range will be made available up to the 16 MW forecast. In both markets, the dispatches will most likely occur at their respective maximum levels of 73 MW for FMM and 16 MW for RTD. In the benefit calculation the base schedule was originally adjusted to the FMM forecast of 73 MW and the load imbalance estimated for this resource was

$$\text{RTD dispatch-adjusted base schedule} = 16\text{ MW} - 73\text{ MW} = 57\text{ MW}$$

As a result, the cost estimate for the WEIM case will reflect an imbalance of 57 MW. However, this imbalance does not represent an actual market redispatch; t's simply a measure of the forecast differences between FMM and RTD. The WEIM market was not dispatching the resource down by 53 MW from its base schedule; instead, it was acknowledging that the resource could only produce up to the RTD forecast of 16 MW.

With the enhanced logic, the calculation for this resource now better reflects the actual conditions in the RTD market. Since the bid range available in RTD is capped at 16 MW, the adjusted base schedule is now 16 MW.

The estimated load imbalance for this resource is calculated as:

$$\text{RTD dispatch-adjusted base schedule} = 16\text{ MW} - 16\text{ MW} = 0\text{ MW}$$

This 0 MW imbalance reflects the scenario where the market is not redispatching the resource down. Instead, it simply accounts for the adjustment in the forecast available in RTD. Therefore, there is no WEIM cost associated with this resource.

As the mix of market resources in the WEIM footprint continues to evolve, the ISO has identified a second enhancement aimed at improving the modeling of storage resources in the counterfactual calculation.

Prior to Q4 2025, storage resources were modeled like any other conventional resource: an available dispatch range was estimated, and based on the resource's price, a counterfactual dispatch was determined. However, storage resources have unique limitations that must be considered in the counterfactual, particularly those related to managing the state of charge.

This enhancement addresses three key areas:

1. Adjusting the Maximum Bid Limit Based on available State of Charge: The maximum bid limit for storage resources will now account for their available state of charge. While a storage resource may be dispatched according to its price-quantity bid, any dispatch must be supported by sufficient state of charge.

2. Respecting the Minimum State of Charge: Storage resources can define a minimum state of charge. The counterfactual dispatch will now enforce this constraint, ensuring that the resource is dispatched in a way that maintains its state of charge above this minimum level.

3. Enforcing End-of-Hour Constraints: Storage resources may also define an end-of-hour constraint, ensuring that the resource is dispatched in a way that allows it to stay within this constraint by the end of the hour. This constraint is now considered in the determination of the counterfactual dispatch.

In cases where a counterfactual dispatch does not have sufficient supply offers to meet net load imbalance, we assign a penalty cost for procuring more energy. If the BA does not import from EIM, we extend its last economic bid segment. If the BA imports from EIM, we compare its last economic segment against the EIM LMP, and set the penalty price to the higher of the two. In summary, the penalty price per MWh is

- The highest offer price from the BA if the BA does not import from EIM,
- Max (the highest offer price from the BA, the transfer LMP) if the BA imports from EIM.

An EIM BAA may restrict the pool of dispatchable units in the counterfactual dispatch if that the BAA's practice prior to joining EIM was to balance real-time load from a limited pool.

ISO Counterfactual Dispatch

The ISO would need to meet load without EIM transfers in the counterfactual dispatch. The counterfactual dispatch is constructed in the following way:

1. Calculate the ISO's net EIM transfer;
2. Economically dispatch resources from the ISO to replace the transfer
   A. If the ISO is importing from the EIM,
      a. Find the ISO's undispatched supply with the variable cost (bid and three-part converted) greater than or equal to the reference transfer price;
      b. Sort and stack the supply by the variable cost from low cost to high cost; and
      c. Clear the supply stack from low cost to high cost up to the transfer megawatts
   B. If the ISO is exporting to the EIM,
      a. Find the ISO's dispatched supply with the variable cost (bid and three-part converted) less than or equal to the reference FMM transfer price;
      b. Sort and stack them by the variable cost from high cost to low cost; and
      c. Clear the supply stack from high cost to low cost up to the transfer megawatts

The reference transfer price for the ISO is the maximum price of the incoming transfer points if the ISO is a net transfer importer, and the minimum price of the outgoing transfer points if the ISO is a net transfer exporter in RTD. Undispatched supply at lower bid cost than the reference price is dispatched out of merit when the ISO is importing transfer at the reference price. Dispatched supply at higher bid cost than the reference price is also dispatched out of merit when the ISO is exporting transfer at the reference price. The ISO has complex networks and constraints that are modeled in the EIM but not in the counterfactual. For example, supplies can be locally transmission constrained and undispatched in the EIM, which have available supply at lower bid cost than the LMP of the rest of the ISO. They should remain undispatched in the counterfactual even they have lower supply cost, because they are constrained by transmission. In the ISO's counterfactual dispatch, we only consider supplies above the reference transfer price to replace incoming transfer into the ISO, and thus preventing the transmission constrained lower cost supply being dispatched. Vice versa for the supplies below the reference transfer price to replace outgoing transfer. The counter factual dispatch (applies for whole EIM, not just the ISO) was based on 5-minute dispatch capability, and the reference price is the RTD price.

Counterfactual Dispatch

All EIM entities, with the exception of Pacificorp, have their counterfactual dispatch constructed in the following way. We will use NVE as an example.

1. Calculate the real-time net load imbalance for NVE;
2. Economically dispatch resources from NVE on top of the base schedules to meet NVE's net load imbalance
   A. If the net load imbalance is positive,
      a. Dispatch NV Energy's bid-in supply above base schedules;
      b. Sort and stack them by the variable cost from low cost to high cost; and

c. Clear the supply stack from low cost to high cost up to the net load imbalance.

B. If the net load imbalance is negative,

a. Dispatch NV Energy's bid-in supply below base schedules;

b. Sort and stack them by the variable cost from high cost to low cost; and

c. Clear the supply stack from high cost to low cost up to the net load imbalance.

PacifiCorp Counterfactual Dispatch

PacifiCorp East BAA and PacifiCorp West BAA would need to meet demand without intra-hour transfers between PacifiCorp and the ISO, but transfers could occur between PACE and PACW in the counterfactual dispatch. The PacifiCorp counter factual dispatch will be constructed in the following way:

1. Calculate the real-time net load imbalance for each BAA;
2. Economically dispatch resources from PacifiCorp on top of the base schedules to meet net PacifiCorp load imbalance without violating the transfer limitations between PACE and PACW.

A. If the net load imbalance is positive,

a. Find PacifiCorp's bid-in supply above base schedules;

b. Sort and stack them by the variable cost from low cost to high cost; and

c. Clear the supply stack from low cost to high cost up to the net load imbalance subject to the transfer limit between PACE and PACW

B. If the net load imbalance is negative,

a. Find PacifiCorp's bid-in supply below base schedules;

b. Sort and stack them by the variable cost from high cost to low cost; and

c. Clear the supply stack from high cost to low cost up to the net load imbalance subject to the transfer limit between PACE and PACW

GHG Revenue

Greenhouse gas (GHG) revenue for a resource is equal to its GHG allocation MW times the GHG price.

GHG Cost

GHG cost for a resource is equal to its GHG allocation MW times its GHG bid.

Example

This example illustrates how the EIM benefit is calculated.

The transfers out of the EIM optimization are listed in Table 1. Base scheduled transfers have been excluded in the FMM transfers and RTD transfers.

From BAA	To BAA	FMM transfer	FMM transfer price	RTD incremental transfer	RTD transfer price	Transfer cost
PACE	NEVP	140	$26	10	$25	$3,890
NEVP	CISO	160	$26	20	$30	$4,760
PACE	PACW	190	$26	10	$25	$5,190
PACW	CISO	110	$26	-10	$30	$2,560

Table 1. An example of BAA to BAA transfers and prices

Assume the EIM energy imbalance and prices are as follows. Every BAA is balanced with Gen + Transfer – Load = 0. Assume the EIM optimization results in $1 GHG price, which means the ISO's LMP is $1 higher than the neighboring BAA (NEVP and PACW), because there is no congestion going into the ISO in the example. In the table below, positive transfer MW means the BAA is importing and negative transfer MW means it is exporting. Also, transfers in the table are sum of the transfers occur in both the FMM and the RTD with base scheduled transfer being excluded.

BAA	Gen	Load	Net transfer in MW	LMP	GHG price
CISO	0	280	280	$31	$1
NEVP	50	20	-30	$30	
PACE	150	-200	-350	$20	
PACW	100	200	100	$30	

Table 2. EIM energy imbalance and prices by BAA for one 5-minute interval

Transfer Cost

The transfers occur in both FMM and RTD, and their volume and prices are listed in Table 3. They are calculated from applying the convention that importing is positive and exporting is negative the BAA to BAA transfers, and summing them over all the neighboring BAAs.

BAA	transfer cost
CISO	$7,320 = $4,760+$2,560

NEVP	($870) = $3,890-$4,760
PACE	($9,080) = -$3,890-$5,190
PACW	$2,630 = $5,190-$2,560

Table 3. EIM transfer cost by BAA

For flex ramp, we calculate its transfer and transfer cost in Table 4.

BAA	Direction	Req.	Award	Allocation	Flex ramp transfer in	Flex ramp price	Flex ramp transfer cost
CISO	upward	150	100	75	-25	$1	-$25
NEVP	upward	10	0	5	5	$1	$5
PACE	upward	20	0	10	10	$1	$10
PACW	upward	20	0	10	10	$1	$10
CISO	downward	0	0	0	0	$2	$0
NEVP	downward	10	10	2	-8	$2	-$16
PACE	downward	20	0	4	4	$2	$8
PACW	downward	20	0	4	4	$2	$8

Table 4. Flex ramp transfer example

EIM Dispatch Cost

Now calculate the total bid cost associated with the EIM dispatches (delta from base schedules). The EIM dispatch costs are listed in Table 5.

BAA	Gen_EIM	EIM dispatch cost
CISO	0	$0
NEVP	50	$1,450
PACE	150	$2,700
PACW	100	$2,800

Table 5. EIM dispatch cost by BAA

Counterfactual Dispatch Cost

Then construct the counterfactual dispatches as described in the previous section, and sum up the counter factual dispatch cost for each BAA as shown in Table 6.

BAA	Gen_CF	Counterfactual dispatch cost
CISO	280	$9,240
NEVP	20	$640
PACE	-200	($3,800)
PACW	200	$6,200

Table 6. Counterfactual dispatch cost by BAA

GHG Cost and Revenue

The GHG costs associated with the 280 MW of importing transfer into CISO, and the revenues received by the GHG allocated MWs in both FMM and RTD are listed in Table 7.

BAA	GHG FMM MW	GHG RTD MW	GHG cost	GHG revenue
CISO	270	280	$0	-$280
NEVP	0	0	$0	$0
PACE	200	200	$20	$200
PACW	70	80	$75	$80

Table 7. GHG cost and revenue by BAA

EIM Benefit

With all the cost and revenue for each BAA available, we can use the formula EIM benefit for a BAA = counterfactual dispatch cost – (EIM dispatch cost + transfer cost + flex ramp transfer cost) + GHG revenue – GHG cost to calculate EIM benefit for each BAA. The results are shown in Table 8.

BAA	CF dispatch cost	EIM dispatch cost	Transfer cost	Flex transfer cost	GHG cost	GHG revenue	EIM benefit
CISO	$9,240	$0	$7,320	($25)	$0	($280)	**$1,665**

NEVP	$640	$1,450	($870)	($11)	$0	$0	**$71**
PACE	($3,800)	$2,700	($9,080)	$18	$20	$200	**$2,742**
PACW	$6,200	$2,800	$2,630	$18	$75	$80	**$757**

Table 8. EIM benefit for one 5-minute interval

This calculation is performed for each 5-minute interval with unit $/hr. We convert the $/hr benefit into the dollar benefit by multiplying 1/12. Then the 5-minute interval benefits in dollar amount can be aggregated into the monthly benefit by summing all the 5-minute intervals in the month.